

South Third Avenue Bridge
(Rainbow Arch Bridge)
Spanning Linn Creek on South Third Avenue
Marshalltown
Marshall County
Iowa

HAER IA-8

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IOWA,
64-MARS,
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PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

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HISTORIC AMERICAN ENGINEERING RECORD

South Third Avenue Bridge
(Rainbow Arch Bridge)

IA-8

Location: Spanning Linn Creek on South Third Avenue in
Marshalltown, Marshall County, Iowa

Date of Construction: 1920

Present Owner: City of Marshalltown
Municipal Building
P.O. Box 757
Marshalltown, Iowa 50158

Present Use: Vehicular and pedestrian bridge

Significance: The South Third Avenue bridge in Marshalltown is one of fifteen known concrete rainbow arch bridges in Iowa. It is considered an important structural form in the development of reinforced concrete technology and illustrates Iowa's significant civil engineering heritage. It was designed by the Marsh Engineering Company of Des Moines, Iowa, for the City of Marshalltown. James B. Marsh also was granted the U.S. patent for this bridge style. Also considered important is the fact that the interior reinforcing varies from that specified in the original patent and, in some details, varies from the design plans.

Project Information: This documentation fulfills the obligations of the Iowa Department of Transportation and the Federal Highway Administration under a Memorandum of Agreement between the Federal Highway Administration, the Iowa State Historic Preservation Officer, and the Advisory Council on Historic Preservation, pursuant to 36 CFR 800. The bridge was photographed in November, 1979, by Grau Studios, Marshalltown, Iowa and printed by Dennett, Muessig, and Associates, Ltd., Iowa City, Iowa, in February, 1981.

Researchers:	David L. Cook	Iowa DOT	February, 1981
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On May 18, 1920, James B. Marsh sent to city engineer, O.G. Herm, a print of plans for falsework, centering and forms for a 106-foot Rainbow Arch bridge over Linn Creek on South Third Avenue in Marshalltown, Iowa.¹ The bridge was constructed that same year by N.M. Stark and Company of Des Moines, Iowa. Its location lies immediately south of the Third Avenue viaduct over the Chicago and Northwestern railroad tracks (Fig. 1). Third Avenue was the route of U.S. 30 prior to 1947 and also the route of Iowa 14 until 1951. Today it is FAUS Route 4699 and is under the jurisdiction of the City of Marshalltown.

The South Third Avenue viaduct passes over the tracks and the west end of the classification yard of the Chicago and Northwestern Railroad. To the north of the railroad yard are an industrial and warehouse district, Marshalltown's central business district, and the city's older residential area. In the southern portion of the city are the newer commercial and residential areas. Immediately south of Linn Creek in the vicinity of the Rainbow Arch Bridge are a number of industrial buildings which date from the latter part of the nineteenth century. Included are buildings of the Diamond Paint Products Company, the oldest of which was constructed about 1870 to serve as a linseed oil mill.

The typical Marsh Rainbow Arch bridge is a hybrid of the continuous concrete and the segmented steel arch designs. James B. Marsh was granted patent number 1,035,026 on August 6, 1912, for his design which provided for "certain new and useful Improvements in Reinforced Arch Bridges." The bridge was designed to permit a limited amount of expansion and contraction both of the arches and of the floor, these being the longest members of the bridge.²

This bridge structure consists of a pair of two foot six inch wide reinforced concrete arch ribs springing from the abutments which are located on either side of Linn Creek. The arches are asymmetrical due to a grade which makes the spring line elevation on the north two feet higher than on the south. The arches are reinforced with eight 1 1/4-inch square reinforcing bars which are tied together by 1/2-inch diameter bar spacers. Additional steel, consisting of two 1 1/4-inch square reinforcing bars sixteen feet long, was placed in the top of the arch ring near the haunches of each arch. The use of reinforcing bars varies from the original patent in which the arches were reinforced by four large steel angles laced together by smaller steel angles. The reasons for this variance from the patent are not evident. However, the steel angle reinforcement as illustrated in the patent would have to be prefabricated requiring additional time to complete the bridge. The square reinforcing bars used were standard stock available from suppliers and assembled by laborers at any construction site. They were supplied in standard sizes and were spliced to the length needed to accommodate the asymmetrical shape of the arch. The disadvantage of the reinforcing bars was that they required more falsework to support them during assembly than prefabricated steel angle reinforcement.³

The arch span measures 106 feet at the springing line with a maximum rise of 23 feet to the intrados. The arches have a maximum radius to the intrados of 77.38 feet and a maximum radius to the extrados of 85.79 feet. The overall length of the structure is 154 feet with the arch supported section measuring 106 feet and the approaches 24 feet each. The roadway measures 24 feet in width and the six foot wide pedestrian sidewalks are supported from the cantilevered ends of the floorbeams on each side outside

of the arches. Provision was made for a double track street car line (12 foot center to center) down the middle of the roadway.⁴ The handrailing is of the concrete skeleton type with eighteen openings per bay, each bay being 17 feet 5 inches in length except the four end bays which measure 14 feet 2 inches in length and contain fourteen openings.⁵

A reinforced concrete beam spanning the roadway was added to the top of the arches at the time of construction, but was not included in the design sheets. Presumably, it was decided to add this feature after the final design had been approved. This beam supported three electrical lines on each arch side. A decorative design utilizing three inset panels, similar to that used for the bridge structure, was impressed into the cement beam.

The longitudinally reinforced concrete deck is supported by nine transverse floorbeams which are suspended from a series of nine hangers spaced at nine foot six inch intervals along each arch rib support. The hangers are each reinforced with two 1 1/2 x 7/8 inch loop bars. These suspend from 2 1/2-inch diameter pins which pass through four 1/2-inch thick x 6-inch wide plates attached to the eight reinforcing bars in the arches. Additional support is provided for these plates by four "U-shaped" 3/4-inch square reinforcing bars embedded into the concrete of the arch. As previously noted, the use of reinforcing bars in the construction of the arches and hangers of this bridge varies from the original patent which used steel angles for reinforcement. The floorbeams and the deck also contain reinforcing bars.⁶

Longitudinal curbs run along each edge of the 24 foot wide roadway slab. The slab, curbs and sidewalks are constructed 1/2-inch clear of the arch ribs where they pass through the plane of the bridge deck to allow for movement at these locations. Additional expansion is provided between the deck slab and the abutments above the springing.⁷

Both arch ribs are founded on reinforced concrete abutments supported on creosoted timber piling. Individual arch footings are tied together by the abutment backwall and a toewall adjacent to the creek. Reinforced concrete T-beams supporting a reinforced concrete deck span the 24 foot roadway from above the springing to the abutment backwall at either end of the structure.⁸

This bridge was submitted by the City Engineer of Marshalltown to the Iowa Highway Commission for analysis in 1919. William N Adams, employed at the time "by the Iowa Highway Commission as Draftsman, Checker and Designer", used this bridge for the example in his master's thesis on stress analysis of arches. He concluded that, compared to Highway Commission standards, the arch rib is overstressed 25% and the abutment overstressed 40%. A heavier arch rib section and a few more pilings near the rear of the abutments would bring the bridge to standards. However, no construction records have been found to indicate if these recommendations were followed.⁹

Presently, the bridge is in poor repair, with reinforcing steel exposed in numerous areas. In 1975, a Structural Inventory and Appraisal was performed and it concluded that the bridge had no remaining life due to its deteriorated condition.¹⁰

CONSTRUCTION HISTORY

The Marshalltown city council opened bids for a new bridge to span Linn Creek on South Third Avenue on Monday, April 5, 1920. The old structure had long been considered unsafe for heavy traffic and in need of replacement. The city had previously considered various bridge plans in 1918, but nothing was done at that time. Three local firms and a firm from

Des Moines now entered the bidding. Peterson and Bates of Marshalltown submitted a bid of \$34,796 for a steel truss structure, exclusive of abutments. Ingersoll-Stouffer of Marshalltown bid \$39,000 to build a concrete structure or \$40,000 for an alternate plan using structural steel for reinforcing. Coburn and Watson also of Marshalltown bid \$36,929 for a concrete structure. Stark Company of Des Moines bid \$38,000 to build a concrete structure which they promised to have completed within 145 days of signing the contract. These bids all excluded costs for paving, piling and extra concrete.¹¹

After much consideration of the merits of concrete and steel bridges, the city council on April 19 awarded the contract to the N.M. Stark Company of Des Moines for their rainbow arch design. The contract specified that work was to begin within 45 days and be completed by October 1, 1920. The foundation depth was fixed at 21.50 feet above the city datum plane. An additional charge of \$500 per foot for each abutment would be added if it became necessary to increase the depth of the foundation. A reduction of \$500 per foot would be allowed if the foundation depth was decreased.¹²

One sidewalk, two posts and a handrail were all that remained to be completed of the bridge structure by November 26, 1920. The floor, ribs and floorbeams had been run the previous week. The fill for the approaches, which would be done by city crews, also awaited completion. The north approach would require 1200 cubic yards of fill and the south approach needed 800 cubic yards. This would be obtained from the creek bank near the bridge and would require ten days to two weeks to complete. The completion of the bridge was delayed beyond its October 1st deadline by difficulty in getting material.¹³

The bridge was formally opened at 2:45 p.m., Thursday afternoon, December 16, 1920. The fill had been completed shortly before noon. Falsework used in building the bridge was be left in place through the winter for added strength.¹⁴

THE RAINBOW ARCH BRIDGE AS A SIGNIFICANT STRUCTURAL FORM

The Rainbow Arch bridge possesses historical value and is a visually pleasing structural form lending aesthetic richness to the Iowa landscape. Although the use of the arch form in reinforced concrete dates to 1889, the flat slab mode of construction was the most common for reinforced concrete bridges in early 20th century America. It was not until after World War I that reinforced concrete arch bridges became popular. James Marsh promoted the rainbow arch during the 1920's as being among the most economical bridge types for relatively short-spans.¹⁵ This made it quite satisfactory to many of the local governments of the midwest because it did not strain their financial resources. These bridges represent an important structural form within the historical development of reinforced concrete technology and provide evidence of Iowa's long and diverse civil engineering heritage.¹⁶

Recent surveys have uncovered fifteen "rainbow" arch type bridges in Iowa, most of which are located on the secondary road system.¹⁷ Several rainbow arch bridges exist in other midwestern states. In addition to the structure which crosses Linn Creek in Marshalltown, there is a Rainbow Arch bridge crossing Timber Creek at Shady Oak east of Marshalltown on old U.S. 30. There is also one located on U.S. 18 over the Winnebago River near the eastern edge of Mason City, Iowa,¹⁸ and a 270 foot long, three arch structure located in Calhoun County, Iowa. These are among the earliest and largest known examples of the type in the State of Iowa.

MARSHALLTOWN'S DEVELOPMENT IN HISTORICAL CONTEXT

The town of Marshall, Iowa was incorporated in 1863 and is the seat of Marshall County. The name was later changed to Marshalltown to prevent confusion with another town named Marshall.

Linn Creek effectively divides north and south Marshalltown and forms the eastern border of the northern part of the city. The creek was known from the early days of the settlement for its ability to flood with very little warning. News accounts of 1878 record three drownings and several narrow escapes from the flood waters of Linn Creek.¹⁹ Thus, it became evident early in the history of Marshalltown that good bridges across Linn Creek would be important in the development of the community.

Marshalltown's industrial development began soon after the Civil War with the establishment of flannel, blanket, woolen goods, wagon and carriage factories, and an iron foundry. By 1905, Marshalltown had fifty-six factories providing work for hundreds of local people and paying wages of \$300,000 annually.²⁰

The Chicago, Iowa, and Nebraska Company completed railroad tracks into the community in 1863. Other railroads followed and repair shops and a terminal for the Central Railroad of Iowa were built in 1869. Eventually many of the railroads were consolidated and the Chicago and Northwestern became the major railroad company in the community.²¹

Today, Marshalltown is a major center in the area for medical facilities, major retail outlets, cultural opportunities and employment. Public transit is provided by Marshall Motor Coach, Inc. and two taxi companies. There is daily freight service with the Chicago and Northwestern Railroad, charter air service through Neiderhauser Memorial Municipal Airport and intercity bus lines.

The South Third Avenue Rainbow Arch Bridge has formed an important link connecting the northern and southern sections of Marshalltown. In a city which today has a population of more than 26,000, it is one of six bridges over Linn Creek. Prior to 1947, the bridge carried U.S. 30 and it was the route of Iowa 14 until 1951. Today the bridge is under jurisdiction of the city of Marshalltown and carries an average daily traffic of over 14,000 vehicles.²² The Iowa Department of Transportation is considering an improvement which would again route Iowa 14 traffic on part of South Third Avenue from East Anson Street over Linn Creek and the Chicago and Northwestern viaduct to East Linn Street.

THE DESIGNER

James Barney Marsh, who was born in 1856 at North Lake, Wisconsin, moved to Iowa at the age of 18 to attend preparatory school at Fredericksburg. Subsequently, he graduated from Iowa State College of Agriculture and Mechanic Arts, Ames, Iowa, with a Bachelor of Mechanical Engineering degree in 1882.²³ He was a pioneer Des Moines, Iowa, bridge contractor and president of the Marsh Engineering Company. He died June 26, 1936, in Des Moines.

According to a professional biography published in April, 1912, in a directory of graduates from the Division of Engineering of Iowa State College, Marsh's first job after graduation was with the Des Moines office of the King Bridge Company of Cleveland, Ohio. Marsh's initial association with the King Bridge Company lasted from March, 1883 through March, 1887. During that time his duties included the design and marketing of metal bridges, as well as the supervision of the erection of such structures.²⁴

From March, 1887 to March, 1889, Marsh worked for the Kansas City Bridge and Iron Company, serving as head of their northern agency office located in Des Moines. Then, in 1889, he returned to the King Bridge Company to become its General Western Agent and Contracting Engineer. Marsh remained in this capacity until March, 1896, when he established a private practice as a consulting and contracting engineer.²⁵

Marsh remained in private practice until the early 1930's. He worked independently from 1896 to 1904 when he incorporated as Marsh Bridge Company and, subsequently in 1909, the company was reorganized and became known as the Marsh Engineering Company.²⁶

Among the earliest bridges designed by Marsh after he entered private practice were those over the Chippewa River at Eau Claire, Wisconsin, and over the Red River at Alexandria, Louisiana. Also, during the initial years when he was on his own, James Marsh often contracted bridges which he designed. One such structure for which he functioned as both designer and contractor was the Huefano Street Bridge in Colorado Springs, Colorado.²⁷

It was apparently about 1900 that Marsh began to specialize in the design of reinforced concrete structures. During 1902 and 1903 Marsh designed concrete bridges for Kankakee and Peoria, Illinois, and for Kenosha, Wisconsin. Somewhat later he also designed three reinforced concrete bridges for three of Iowa's larger cities. These Iowa bridges designed by Marsh were the Walnut Street Bridge in Des Moines, the Second Avenue Bridge in Cedar Rapids, and the Fourth Street Bridge in Waterloo. In addition, it is known that Marsh undertook a substantial number of contracts for the Iowa State Highway Commission.²⁸

FOOTNOTES

- 1 Letter from James B. Marsh, Chief Engineer, Marsh Engineering Company, to O.G. Herm, City Engineer, Marshalltown, Iowa; May 18, 1920.
- 2 United States Patent Office, Patent Number 1,035,026: Reinforced Arch Bridge. James B. Marsh, Des Moines, Iowa; August 6, 1912.
- 3 Design for Marsh Rainbow Arch Bridge over Linn Creek at South Third Avenue, City of Marshalltown, Iowa. By J.B. Marsh, Consulting Engineer, Des Moines, Iowa; January, 1919.
- 4 Adams, William N.; 1919. Arch Rib Analysis of a 106' Unsymmetrical Rainbow Arch Bridge at South Third Avenue, Marshalltown, Iowa. Unpublished master's thesis. Iowa State College, Ames, Iowa. p. 4.
- 5 Design for Marsh Rainbow Arch Bridge; January, 1919.
- 6 Ibid.
- 7 Ibid.
- 8 Ibid.
- 9 Adams, William N., introduction, p. 1, 7.
- 10 Iowa Structure Inventory & Appraisal, South 3rd Avenue over Linn Creek, City of Marshalltown, T84N - R18W, Section 25, by Dennis L. Foderburg, P.E., Howard R. Green Company, Cedar Rapids, Iowa; May 16, 1975.
- 11 Marshalltown Times-Republican; April 5, 1920.
- 12 Ibid., April 20, 1920.
- 13 Ibid., November 26, 1920.
- 14 Ibid., December 17, 1920.
- 15 Letter from Douglas L. Griffin, Chief, National Architectural and Engineering Record, United States Department of the Interior, Heritage Conservation and Recreation Service, to David B. Drake, Environmental Coordinator, Office of Project Planning, Planning and Research Division, Iowa Department of Transportation; March 10, 1978.
- 16 Letter from Adrian O. Anderson, Iowa State Historic Preservation Officer, to Dr. William Murtagh, Keeper of the National Register, U.S. Department of the Interior; May 19, 1978.

- 17 Iowa Department of Transportation, Highway Division, Office of Secondary Roads. Rainbow Arch Bridge Survey; December, 1979.
- 18 Iowa Department of Transportation, Planning and Research Division, Office of Project Planning. Final Environmental Statement and Location Study Report for Iowa 14, Marshall County; May, 1979, p. 170.
- 19 Marshalltown Times-Republican, Bicentennial Edition; June 4, 1976.
- 20 State of Iowa, Federal Writer's Project of the Works Progress Administration, Iowa: A Guide to the Hawkeye State; New York, The Viking Press, 1938; pp. 281-283.
- 21 Marshalltown Times-Republican; June 6, 1949.
- 22 Iowa DOT, Final Environmental Statement; May, 1979, p. 21.
- 23 Alumni Association of Iowa State College. The Alumnus of Iowa State, Vol. XXXII, No. 1. July, 1926, p. 21.
- 24 Nichols, C.S., Directory of Graduates of the Division of Engineering, Ames, Iowa, Iowa State College of Agriculture and Mechanic Arts, p. 112.
- 25 Ibid.
- 26 Ibid.
- 27 Ibid.
- 28 Ibid.

RAINBOW ARCH BRIDGE
SOUTH THIRD AVENUE
MARSHALLTOWN, IOWA

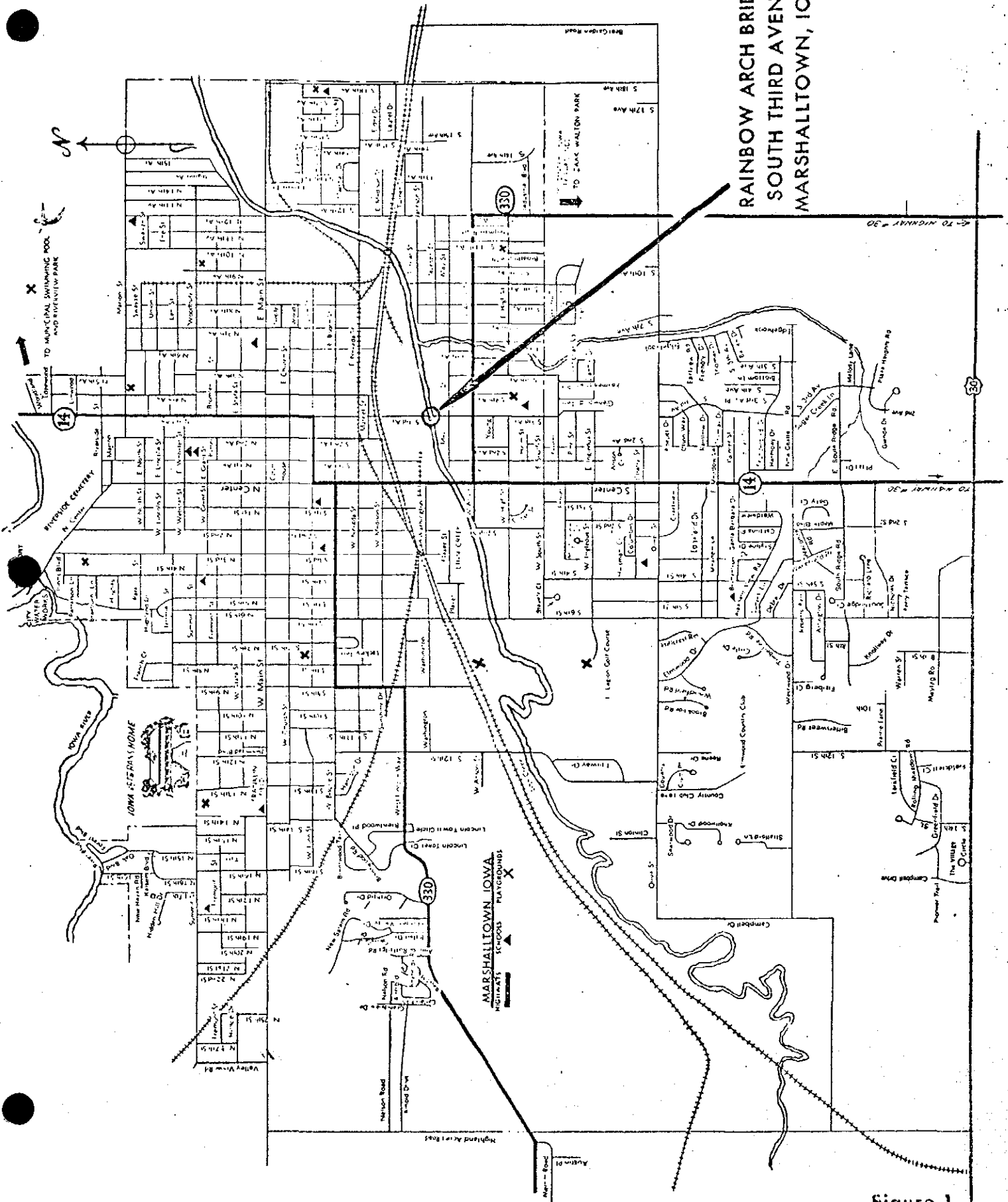


Figure 1